

Implementation of a TOR Bridge

A PROJECT REPORT

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ABSTRACT

The Tor network is a group of volunteer-operated servers that allows people to improve their privacy and security on the Internet. Tor's users employ this network by connecting through a series of virtual tunnels rather than making a direct connection, thus allowing both organizations and individuals to share information over public networks without compromising their privacy.

The design of the Tor network means that the IP address of Tor relays is public. However, one of the ways Tor can be blocked by governments or ISPs is by blacklisting the IP addresses of these public Tor nodes. Tor bridges are nodes in the network not listed in the public Tor directory, making it harder for ISPs and governments to block them. We intend to host our own low-bandwidth Tor bridge on an Ubuntu instance, to monitor and analyze traffic in the Tor network.

1. INTRODUCTION

a) Background of our Proposed Work

These are some important points that we found out during our work on this project and we used these points as reference for implementing our project:

- Bridge relays (or "bridges" for short) are Tor relays that aren't listed in the main Tor directory. Since there is no complete public list of them, even if your ISP is filtering connections to all the known Tor relays, they probably won't be able to block all the bridges.
- Most Pluggable Transports, such as obfs3 and obfs4, rely on the use of "bridge" relays. Like ordinary Tor relays, bridges are run by volunteers; unlike ordinary relays, however, they are not listed publicly, so an adversary cannot identify them easily. Using bridges in combination with pluggable transports helps to disguise the fact that you are using Tor.
- Other pluggable transports, like meek, use different anti-censorship techniques that do not rely on bridges. You do not need to obtain bridge addresses in order to use these transports.

b) MOTIVATION

- The growing use of the Internet among the public masses has increased exponentially over the years and although there is a lot of research on maintaining security and anonymity, security is breached one way or another.
- Fingerprinting attacks and traffic analysis have become common and hence, TOR helps us avoid all that and stay safe and anonymous online.
- But there are new methods of analyzing and fingerprinting even TOR users.
- Hence, we aim to put an end to that by making a bridge not listed on the public consensus, hence ensuring anonymity against the new type of attacks.

c) ISSUES IN EXSISTING SYSTEM

- Your real IP address is leaked to the first node while using TOR.
- ISPs mark your use of TOR by tracking your usage.
- A malicious tech at your VPN provider could try an attempt at sending malicious code down that bridge to you.
- Fingerprinting attacks using technologies like Deep Learning continue to tighten grip on censorship circumvention alternatives.

2. LITERATURE SURVEY

Title	Journal	Year	Abstracts	Drawbacks
Analysis of Fingerprinting Techniques for Tor Hidden Services	WPES	2017	The paper proposes a novel two phase approach for fingerprinting hidden services that does not rely on malicious Tor nodes. In our attack, the adversary merely needs to be on the link between the client and the first anonymization node.	Tor bridge hasn't been taken into account
Fingerprinting Attack on Tor Anonymity using Deep Learning	APAN	2016	This paper proposes a new method for launching a fingerprinting attack to analyse Tor traffic in order to detect users who access illegal websites. Our new method is based on Stacked Denoising Auto encoder, a deep-learning technology	Alternative entry points cannot be detected using this. Also, neural nets can be optimised using RNN instead of CNN
Mind the Gap: Towards a Backpressure-Based Transport Protocol for the Tor Network	HUB	2016	The current Tor design is not able to adjust the load appropriately, and we argue that finding good solutions to this problem is hard for anonymity overlays. It's due to the long end-to-end delay in such networks, combined with limitations allowable feedback due to anonymity requirements.	The destination route can be found easily though the exit point in the network

Title	Journal	Year	Abstracts	Drawbacks
Design, implementation and test of a flexible tor-oriented web mining toolkit	ACM	2017	This paper presents a flexible and accessible toolkit for structure and content mining, able to crawl, download, extract and index resources from the Web using Tor network.	Normal Tor node is being used as an entry point which can be used to get the IP address of the user
Characterization of Tor Traffic using Time based Features	ICISS	2017	In this paper, a time analysis is presented on Tor traffic flows, captured between the client and the entry node. We define two scenarios, one to detect Tor traffic flows and the other to detect the application.	Monitoring the entry node of the Tor network can jeopardize the security of the IP address of the user
A Forensic Audit of the Tor Browser Bundle	Cornell	2019	The Tor browser, though, can leave behind digital artefacts which can be used by an investigator. This paper outlines an experimental methodology and provides results for evidence trails which can be used within real-life investigations	tor bridge has not been taken into account
Forensic Analysis of Tor Browser: A Case Study for Privacy and Anonymity on the Web	FSI	2019	This paper examines the extend of user privacy when he is operating on TOR network and how much exposed he is while he is on network.	N.A .
Ephemeral Exit Bridges for Tor	IEEE	2019	This paper examines an existential threat to Tor---the increasing frequency at which websites apply discriminatory behaviour to users who arrive via the anonymity network. The main contribution is the introduction of Tor exit bridges.	N.A.
The onion router: Understanding a privacy enhancing technology community	IEEE	2020	Tor network is often monitored by law enforcement, which makes this PET is different from any other open-source initiatives. To explore this volunteer community's motivation for providing their services despite the risks, we	PET's mention weren't able to provide the level of privacy that we expect from a tor bridge relay.

Title	Journal	Year	Abstracts	Drawbacks
			conducted an online survey. Study results reveal that one of the main motivations for these volunteers is to advocate and provide privacy for online users.	

SUMMARY:

The final takeaway from all the research paper we read is the TOR is a brilliant implementation of Privacy Enhancing Technologies (PETs) but a serious flaw that we figured out from above papers is the mention of the TOR relays in the public directory where the intruder in the network or the ISP of the user can easily track their entry relay from where they enter the TOR network. Once they figure out the entry node, neural networks can be constructed and optimized for the purpose of tracking the different relays in the network and figuring out the final destination of the user on the network i.e. their exit relay.

By implementing tor bridges, the very cause of the problem can be avoided as the relays of the tor bridges are not mentioned in the public directory, moreover using them to enter the network of tor relays will make sure that the ISP of the user or the cracker cannot track the entry relay of the user.

3. PROPOSED SYSTEM

a. OVERVIEW

The Tor network is a group of volunteer-operated servers that allows people to improve their privacy and security on the Internet. Tor's users employ this network by connecting through a series of virtual tunnels rather than making a direct connection, thus allowing both organizations and individuals to share information over public networks without compromising their privacy.

The design of the Tor network means that the IP address of Tor relays is public. However, one of the ways Tor can be blocked by governments or ISPs is by blacklisting the IP addresses of these public Tor nodes. Tor bridges are nodes in the network that are not listed in the public Tor directory, which make it harder for ISPs and governments to block them. We will also be setting up a system to analyze the TOR Traffic on our bridge.

b. SYSTEM ARCHITECTURE

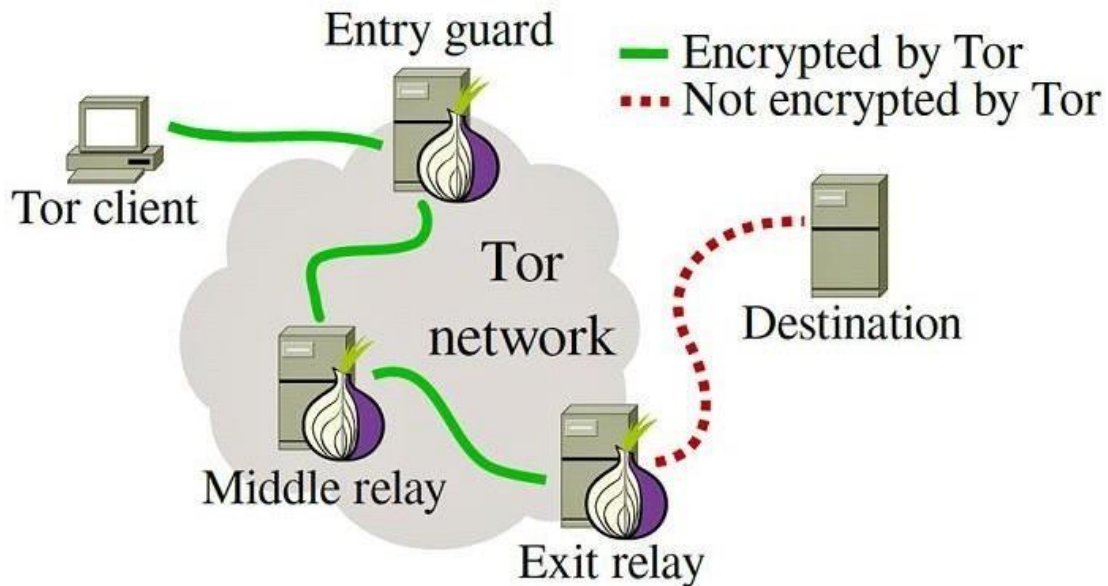


Figure 1: System Architecture of TOR network

The figure 1 above gives us a brief idea on how devices on the TOR network function and their architecture.

TOR network is an implementation of onion routing, which encrypts and then randomly bounces communications through a network of relays run by volunteers around the globe. These onion routers employ encryption in a multi-layered manner to ensure perfect forward secrecy between relays, thereby providing users with anonymity in a network location. That anonymity extends to the hosting of censorship-resistant content by Tor's anonymous onion service feature.

Furthermore, by keeping a few entry relays or bridge relays secret, users can evade Internet censorship that relies upon blocking public Tor relays.

Because the IP address of the sender and the recipient are not both in clear text at any hop along the way, anyone eavesdropping at any point along the communication channel cannot directly identify both ends. Furthermore, to the recipient it appears that the last Tor node (exit node), rather than the sender, is the originator of the communication.

c. FUNCTIONAL ARCHITECTURE

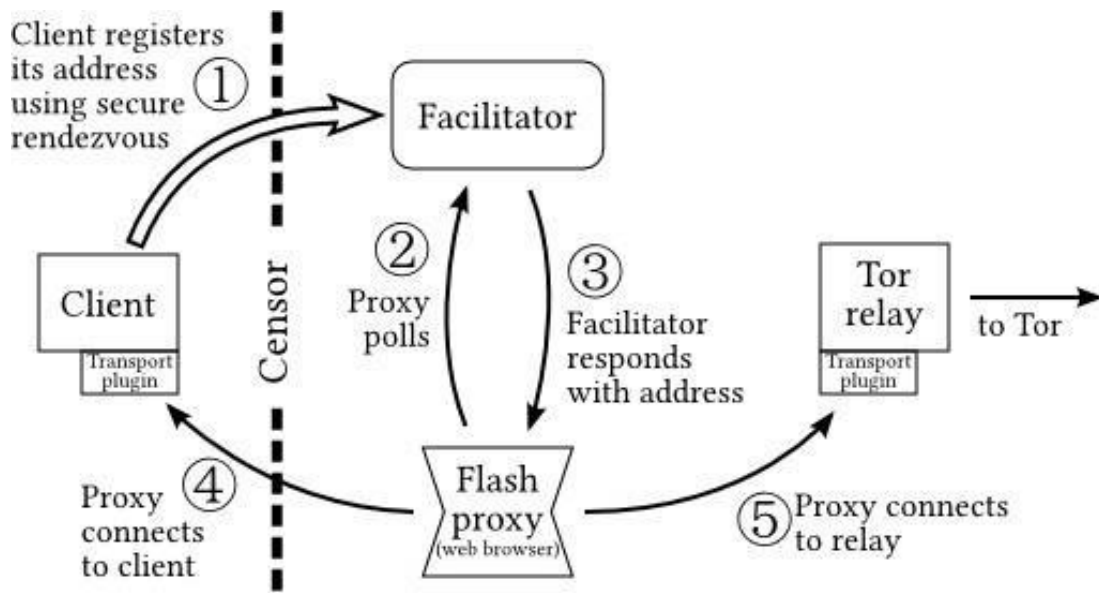


Figure 2: Functional Architecture of TOR network

Figure 2 explains the functioning of the TOR Network in presence of the facilitator which will be the TOR Bridge.

Bridges are useful for Tor users under oppressive regimes or for people who want an extra layer of security because they're worried somebody will recognize that they are contacting a public Tor relay IP address.

Bridges are relatively easy, low-risk and low-bandwidth Tor nodes to operate, but they have a big impact on users. A bridge isn't likely to receive any abuse complaints, and since bridges are not listed in the public consensus, they are unlikely to be blocked by popular services. Bridges are a great option if you can only run a Tor node from your home network, have only one static IP, and don't have a huge amount of bandwidth to donate.

The client first tries to connect with the entry relay of the network which in turn send the user a proxy token signifying that a connection is established and the user has successfully entered the TOR bridge network. The user signal is then bounced between several other relays until it reached its final destination, and the beauty of this network is that a particular node does not know the entire route taken by the signal making it very difficult to tap and eavesdrop on the connection made.

d. DESIGN DESCRIPTION

Our project aims at hosting a Tor Bridge on an Ubuntu Virtual Private Server. This bridge serves as a door to the Tor Network. The visualization of the network and its analysis of the same was made by our team. Figure 3 below gives the overall idea of the design of the TOR network in the presence of our bridge.

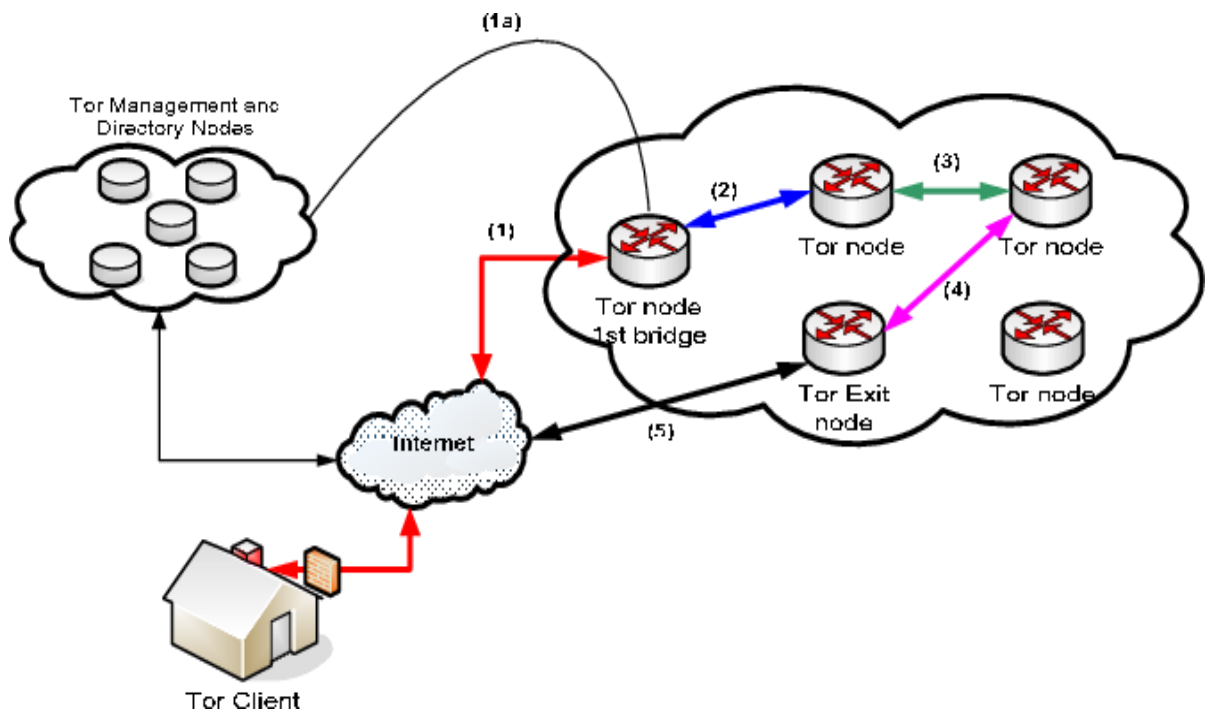


Figure 3: Model Design

e. INNOVATION IN OUR PROJECT

- Unrestricted Access to the TOR network through the Bridge.
- No current method of tracking users in this method.
- Real-time Analysis of parameters like bandwidth usage, logs, and connections, of devices on the TOR network.
- Blacklisting the user's IP address is extremely difficult.

4. Use Cases of our project for Ericsson

- **Research and Development:** Ericsson's research and development team might use Tor Bridge to access online resources and conduct research on new technologies or competitors without revealing their IP addresses or location.
- **Customer Support:** Ericsson's customer support team could use Tor Bridge to communicate with customers who are in regions where Ericsson's services may be censored or blocked by the regime.
- **Data Security:** Ericsson's employees could use Tor Bridge to access company data and systems securely, especially when working remotely or from public Wi-Fi hotspots that may not be secure.
- **Content Delivery:** Ericsson's content delivery network could use Tor Bridge to deliver content to users in regions where internet access may be restricted or censored.
- **Market Analysis:** Ericsson's marketing and strategy teams could use Tor Bridge to analyze online user behavior in regions where internet access is restricted or censored, gaining insights into market trends and customer behavior that might not be available through traditional data sources
- **Secure Remote Access:** Ericsson has employees who need to access sensitive company data remotely, and Tor Bridge can help provide a more secure way to do so. By routing employee internet traffic through Tor Bridge, Ericsson can ensure that the connection is encrypted and anonymized, making it more difficult for hackers and other bad actors to intercept sensitive company information.
- **Enhanced Privacy and Security for Customers:** Many of Ericsson's customers may be concerned about online privacy and security, especially when it comes to using mobile networks. By integrating Tor Bridge into their products and services, Ericsson can offer enhanced privacy and security features to their customers, making their products more attractive to privacy-conscious consumers.
- **Accessing Blocked Content:** In some countries, certain websites and online services may be blocked or censored. By using Tor Bridge, Ericsson can help customers in these countries access blocked content more easily, making their products and services more valuable to customers in these markets.
- **Protecting Intellectual Property:** Ericsson has a lot of intellectual property and proprietary information that needs to be protected from theft and espionage. By using Tor Bridge, Ericsson can add an extra layer of security to their online communications and ensure that their valuable information is kept safe from prying eyes.

5. IMPLEMENTATION

a. SOFTWARE DETAILS

We will be using a cloud server hosted on Google Cloud Platform (GCP). It will be an Ubuntu Instance that will host our own TOR Bridge. The TOR Bridge will run if the server runs. After some users start using our TOR Bridge, we will analyze the traffic through our Bridge using a tool called NYX and will also be visualizing the data using a custom Python code that uses different libraries to represent the IP Addresses of our users on a World Map.

There are some more specifications related to the VM instance and server size required to create the bridge network:

For a network comprising 100 clients, 10 relays (additional relays if bridges are being considered, so 5 more), depending on various factors the specifications for a VM to host such a network are:

- 1) 30 GB of disk space per month of network traffic
- 2) 15 GB Memory per client
- 3) 2.5GHz Processor
- 4) 100 Mbps Bandwidth

The specifications we used on our cloud VM:

Network interfaces

Network interface is permanent

default default (10.138.0.0/20) ▼

ADD NETWORK INTERFACE

Firewalls

☒ Allow HTTP traffic

☒ Allow HTTPS traffic

Network tags

Network tags

http-server https-server ?

Storage

Boot disk

Name	torkhar
Image	ubuntu-2004-focal-v20230302
Size	20 GB
Interface type	SCSI
Type	Balanced persistent disk
Encryption type	Google-managed
Mode	Boot, read/write
Snapshot schedule	None

Deletion protection

☐ Enable deletion protection

When deletion protection is enabled, instance cannot be deleted. [Learn more](#)

Machine configuration

☒ General purpose ☐ Compute optimized ☐ Memory optimized ☐ GPUs

Machine types for common workloads, optimized for cost and flexibility

Try the new C3 machine series. There's no charge for C3 VMs during public preview.

Series


T2D ▼

Powered by AMD EPYC Milan CPU platform

Machine type

Choose a machine type with preset amounts of vCPUs and memory that suit most workloads.

t2d-standard-1 (1 vCPU, 4 GB memory) ▼



	vCPU	Memory
	1	4 GB

[ADVANCED CONFIGURATIONS](#)

Display device

Enable to use screen capturing and recording tools

☐ Enable display device

b. IMPLEMENTATION SNAPSHOTS

i. BANDWIDTH ANALYSIS WITH NYX

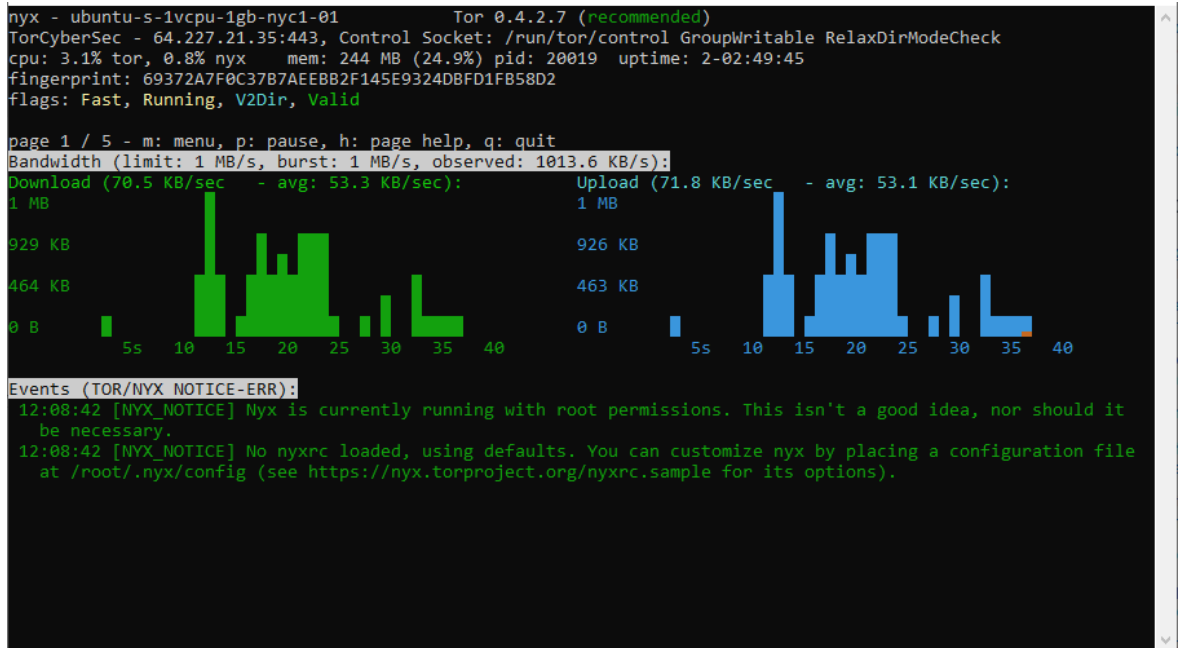


Figure 4: Bandwidth Analysis with NYX

Figure 4 shows the amount of bandwidth used by TOR in terms of the graph and helps us analyze it in case we need to limit the bandwidth. It shows the total data downloaded and uploaded and we can also select the time interval of the graph according to our preference.

ii. RESOURCE ANALYSIS WITH NYX

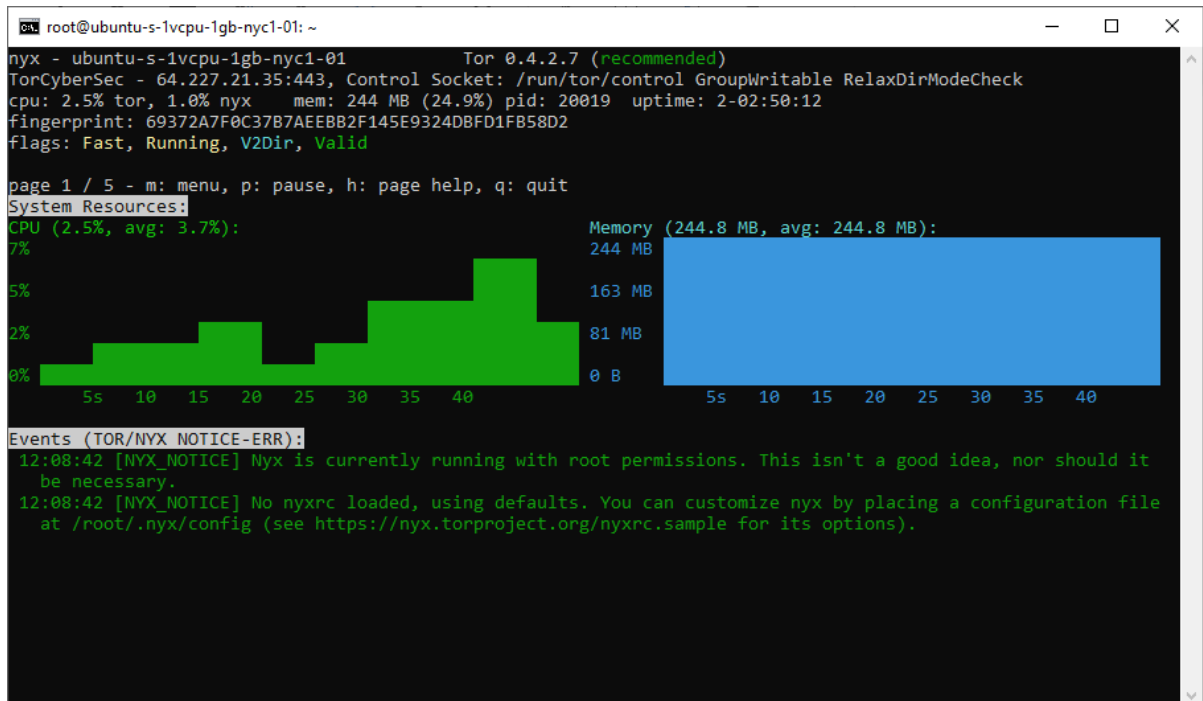


Figure 5: Resource Analysis with NYX

Figure 5 is also a graph generated by NYX to show the system resources being utilized by TOR. Again, like the bandwidth graph, we have the option to customize the time interval here and analyze the use of our resources.

iii. CONNECTION ANALYSIS WITH NYX

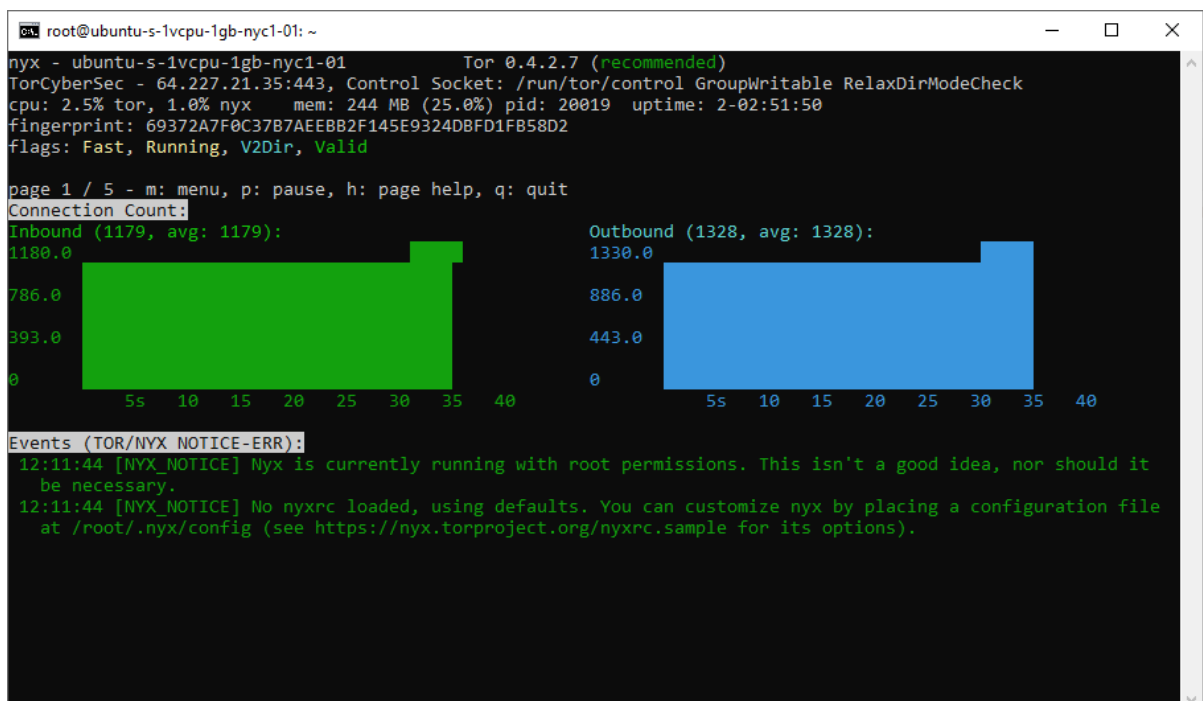


Figure 6: Connection Analysis with NYX

Figure 6 shows a graph generated for the inbound and outbound connections to our TOR Bridge with respect to time. As seen above in the image, it shows that we have 1179 inbound connections and 1328 outbound connections. It helps us analyze how our number of connections changes with time.

6. VISUALISATION OF THE INBOUND CONNECTIONS TO PUT TOR BRIDGE ON A WORLD

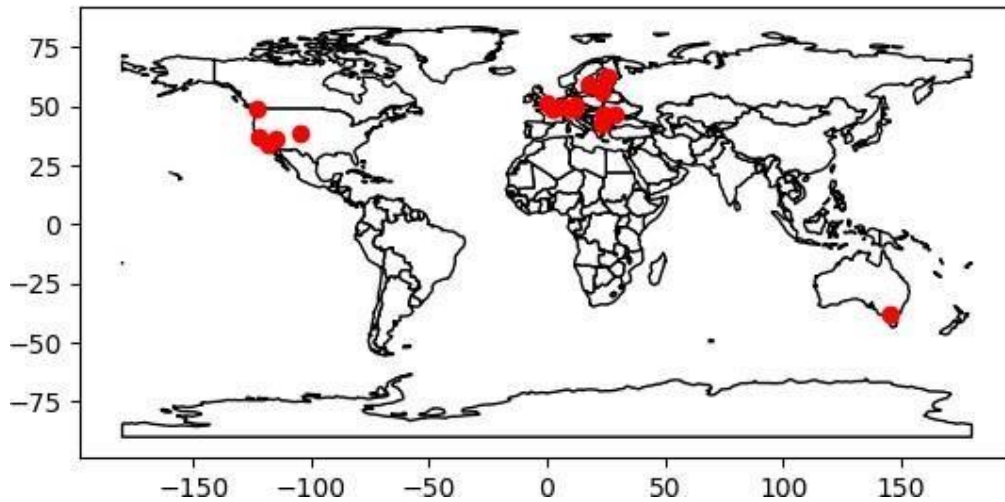


Figure 7: Visualizing the users connected to the TOR Bridge

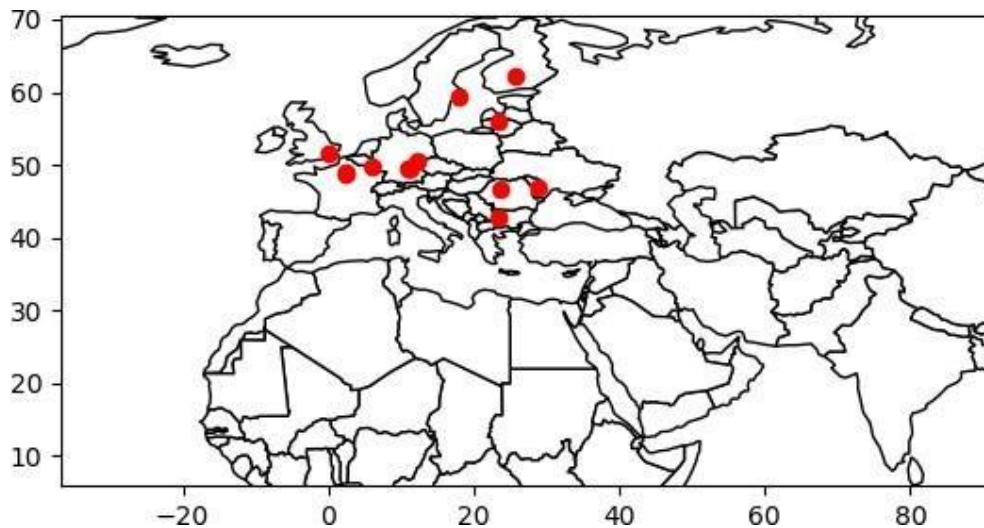


Figure 8: A zoomed-in view of the Visual Map of IP Addresses of TOR Users

Figures 7 and 8 above are the visual representation of the IP Addresses of the people using our TOR Bridge. We wrote a custom Python code that visualizes the users that are using our TOR Bridge through their IP Addresses. The IP Address gives a very good idea about their location, which can be represented on a map.

7. CONCLUSION

So is it worth it? What you made is an isolated network with live information of users accessing the internet via Tor bridges. You could, in fact, create a tor bridge-relay network isolated for your religious cult or terrorist organization. Or you could make one to bring such organizations to light. There are multiple steps implemented to stop users from abusing the Tor network entirely. as the Tor relay database encrypts your IP as a constantly changing public domain... but it doesn't make it vanish. Or change it, entirely. It hides your digital footprint and can be accessed by the peer network admin. For example, The FBI recently closed a criminal case against the owner of Freedom Hosting, a dark web service that ran on the Tor network.

In addition, several research projects have shown varying levels of successful attacks that either attempted to eavesdrop on Tor-encrypted traffic or identify users. Well, that is where tor bridges can successfully revive the old career of TOR Networks where they used to be a thorn in law enforcement.

This project helped us learn extensively about the TOR Network, and the functioning of Tor relays, bridges, and exits which are the backbone of the Tor Network. Also, analysis of the connections, resources, and bandwidth helped us to draft a basic theory about the average usage of the former parameters in a typical Tor Bridge.

The addition of bridges to Tor is a step forward in the blocking resistance race and hence gave us an opportunity to contribute towards internet anonymity and access for all.

8. FUTURE WORK

- More nodes can be generated which will create a TOR bridge network which in turn can be optimized to reduce the latency, noise, or any other kind of delays in the network.
- Optimizing this network, it may make the current method obsolete and pave a path for the users to use a safe internet where neither their activity cannot be traced to their location of access.
- check if two clients communicating with each other can access their IP info or not
- check how an enterprise can successfully implement this network architecture
- create a tor bridge for specifically Enterprise use-cases
- create checkpoints within the network to stop promoting inflammatory content, misinformation

9. CODE SAMPLE

Section 1: TOR CONFIGURATION:

Tor opens a SOCKS proxy on port 9050 by default -- even if you don't

configure one below. Set "SOCKSPort 0" if you plan to run Tor only

as a relay, and not make any local application connections yourself.

SOCKSPort 0

ControlPort 9051

CookieAuthentication 1

Default: Bind to localhost:9050 for local connections.

#SOCKSPort 192.168.0.1:9100

Bind to this address:port too. ## Entry policies to allow/deny SOCKS requests based on IP address. ## First entry that matches wins. If no SOCKSPolicy is set,

we accept

all (and only) requests that reach a SOCKSPort. Untrusted users who

can access your SOCKSPort may be able to learn about the connections

you make.

#SOCKSPolicy accept 192.168.0.0/16 #SOCKSPolicy accept6 FC00::/7 #SOCKSPolicy reject *

Logs go to stdout at level "notice" unless redirected by something

else, like one of the below lines. You can have as many Log lines as

you want. ##

We advise using "notice" in most cases, since anything

more verbose

may provide sensitive information to an attacker who obtains the logs.

##

Send all messages of level 'notice' or higher to

/var/log/tor/notices.log

Log notice file /var/log/tor/notices.log

Send every possible message to /var/log/tor/debug.log Log debug file
/var/log/tor/debug.log

Use the system log instead of Tor's logfiles

#Log notice syslog

To send all messages to stderr:

#Log debug stderr

Uncomment this to start the process in the background... or use

--runasdaemon 1 on the command line. This is ignored on

Windows;

see the FAQ entry if you want Tor to run as an NT service.

#RunAsDaemon 1

The directory for keeping all the keys/etc. By default, we store

things in \$HOME/.tor on Unix, and in Application Data\tor on Windows.

#DataDirectory /var/lib/tor

The port on which Tor will listen for local connections from Tor

controller applications, as documented in controlspec.txt. #ControlPort 9051

If you enable the controlport, be sure to enable one of these

authentication methods, to prevent attackers from accessing it.

#HashedControlPassword

16:872860B76453A77D60CA2BB8C1A7042072093276A3D701AD684053EC4 C

#CookieAuthentication 1

This section is just for location-hidden services

Once you have configured a hidden service, you can look at the
contents of the file ".../hidden_service/hostname" for the address ## to tell people.

##

HiddenServicePort x y:z says to redirect requests on port x to the
address y:z.

#HiddenServiceDir /var/lib/tor/hidden_service/ #HiddenServicePort 80 127.0.0.1:80

#HiddenServiceDir /var/lib/tor/other_hidden_service/ #HiddenServicePort 80
127.0.0.1:80

#HiddenServicePort 22 127.0.0.1:22

This section is just for relays

#

See <https://www.torproject.org/docs/tor-doc-relay> for details.

Required: what port to advertise for incoming Tor connections.

ORPort 443

If you want to listen on a port other than the one advertised in

```
## ORPort (e.g. to advertise 443 but bind to 9090), you can do it as

## follows.      You'll need to do ipchains or other port forwarding

## yourself to make this work. #ORPort 443 NoListen

#ORPort 127.0.0.1:9090 NoAdvertise


## The IP address or full DNS name for incoming connections to your

## relay. Leave commented out and Tor will guess. #Address noname.example.com


## If you have multiple network interfaces, you can specify one for

## outgoing traffic to use.

## OutboundBindAddressExit will be used for all exit traffic, while

## OutboundBindAddressOR will be used for all OR and Dir connections


## (DNS connections ignore OutboundBindAddress). ## If you do not wish to
## differentiate, use

OutboundBindAddress to

## specify the same address for both in a single line. #OutboundBindAddressExit
10.0.0.4

#OutboundBindAddressOR 10.0.0.5


## A handle for your relay, so people don't have to refer to it by key.

## Nicknames must be between 1 and 19 characters inclusive, and must

## contain only the characters [a-zA-Z0-9].

Nickname myfirsttorbridg

## Define these to limit how much relayed traffic you will allow. Your
```

```

## own traffic is still unthrottled. Note that RelayBandwidthRate must
## be at least 75 kilobytes per second.

## Note that units for these config options are bytes (per second), not
## bits (per second), and that prefixes are binary prefixes, i.e. 2^10, ## 2^20, etc.

#RelayBandwidthRate 100 KBytes      # Throttle traffic to
100KB/s (800Kbps)

#RelayBandwidthBurst 200 KBytes # But allow bursts up to 200KB (1600Kb)

```

SECTION 2: VISUALISATION TOOL WITH PYTHON

```

import grequests import argparse import os from platform import system as os_name
import pandas as pd import requests import sqlite3

```

```

lookup_data = []

```

```

def gen_list_urls(relay_data, points):

```

```

    urls = ['http://ip-api.com/json/'+row[1] for row in relay_data[:points]]

```

```

    return urls

```

```

def lookup(urls): """

```

```

    :param: ipaddress to look up

```

```

    :returns: A dict containing all information post lookup """

```

```

    res = (grequests.get(u) for u in urls) consol_res = grequests.map(res) return consol_res

```

```

def index_data_from_cache_file(path): """

```

For reading from cache.sqlite file

:param: path to the cache file

:returns: A list containing tuples where each tuple represents a row [(), (), ()]

"""

```
conn = sqlite3.connect(path) c = conn.cursor()
```

```
relay_data = c.execute('SELECT * FROM relays')
```

```
relay_data = relay_data.fetchall()
```

```
return relay_data def gen_data_frame(path, points):
```

```
raw_data = index_data_from_cache_file(path)
```

```
urls = gen_list_urls(raw_data, points)
```

```
all_responses = lookup(urls)
```

```
cities = []
```

```
countries = []
```

```
lats = []
```

```
longs = []
```

```
for res in all_responses:
```

```
res_data = res.json() cities.append(res_data["city"])
```

```
lats.append(res_data["lat"])
```

```
longs.append(res_data["lon"])
```

```
countries.append(res_data["country"])
```

```
df = pd.DataFrame({'City': cities,
```

```
'Country': countries, 'Latitude': lats, 'Longitude': longs}
```

```
}
```

```
return df
```


10. REFERENCES

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